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# Slime mould: The fundamental mechanisms of biological cognition

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ABSTRACT

The slime mould *Physarum polycephalum* has been used in developing unconventional computing devices for in which the slime mould played a role of a sensing, actuating, and computing device. These devices treated the slime mould as an active living substrate, yet it is a self-consistent living creature which evolved over millions of years and occupied most parts of the world, but in any case, that living entity did not own true cognition, just automated biochemical mechanisms. To "rehabilitate" slime mould from the rank of a purely living electronics element to a "creature of thoughts" we are analyzing the cognitive potential of *P. polycephalum*. We base our theory of minimal cognition of the slime mould on a bottom-up approach, from the biological and biophysical nature of the slime mould and its regulatory systems using frameworks such as Lyon's biogenic cognition, Muller, di Primio-Lengelerś modifiable pathways, Bateson's "patterns that connect" framework, Maturana's autopoietic network, or proto-consciousness and Morgan's Canon.



## 1. Introduction

Classic approaches to cognition were based on human beings, or sometimes, included some great apes or close mammals, leaving unattended a long list of living entities (de Waal, 1999). This biased anthropomorphic perspective had a second problem: it blocked pathways to an evolutionary and naturalistic study of cognition (Atran, 2004). It is easy to find several studies on minimal examples of cognition among prokaryotes (Müller et al., 2001) but the amoeboid organisms of class *Myxogastria* (Myxomycetes) are the best example of the power of such cognitive studies, because they show us the connection bridge between unicellular (*Physarum*) to pluricellular (*Dictyostelium*) living systems. Thus, *Physarum polycephalum* shows to be an extremely intelligent system which offers unique ways for the understanding of the emergence of complex behaviours and cognitive strategies (Dussutour et al., 2010; Shirakawa et al., 2011; Mori and Koaze, 2013). The mapping of such minimal cognitive elements in slime mould also makes the analysis of two different but fundamental ideas possible: first, to identify the computational nature of basic cognitive processes, which in our case offer a good example of a reliable Kolmogorov–Uspensky biomachine; this biocomputational approach offers a naturalistic way to explain the intricacies of informational processing from scratch to the supervenience of proto-consciousness. This process can be explained without relying on any anthropomorphic bias thanks to implementation of the Morgan's Canon. As a consequence, slime mould offers a unique and special biological framework for the identification of the basic biocomputations that make cognition possible and pave the way for the emergence of consciousness (understood as meta-level of informational processing). In the next section we describe in more detail the value of such selection for the study of cognition.

## 2. Minimal cognition: the bottom-up approach to cognition

After the long and intense analysis of human, primate and mammalian cognition, the necessity of explaining their evolutionary and

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